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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04N 7/18

A1

(11) International Publication Number: WO 97/08897

(43) International Publication Date: 6 March 1997 (06.03.97)

(21) International Application Number: PCT/US96/13600

(22) International Filing Date: 22 August 1996 (22.08.96)

(30) Priority Data:
08/518,314 23 August 1995 (23.08.95) US

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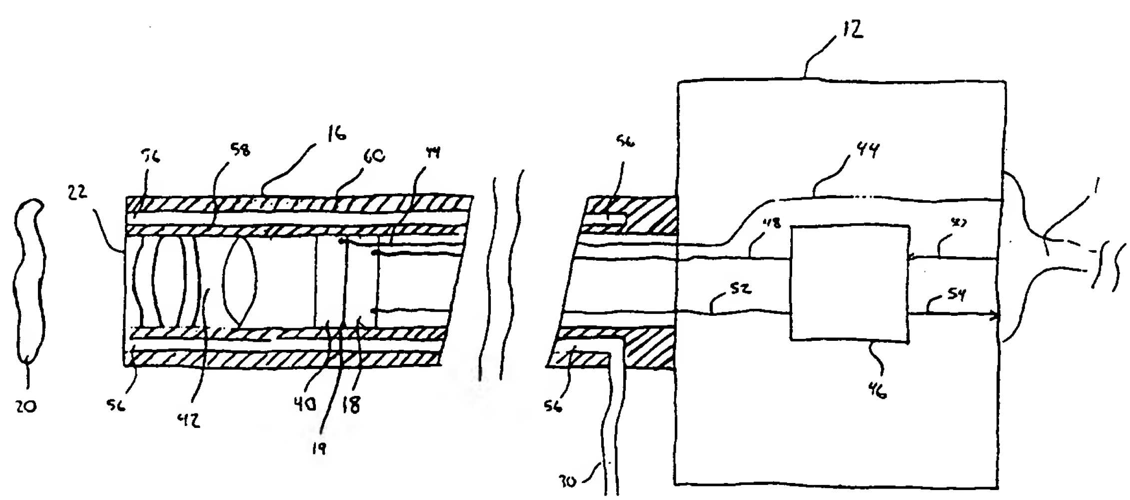
(81) Designated States: AU, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: REMOTE VIDEO DISPLAY SYSTEM WITH LIQUID CRYSTAL COLOUR FILTER



(57) Abstract

An apparatus for viewing an object includes a solid-state colour filter (40) and an imager (18) such as a charge coupled device. The solid state colour filter (40) is operable to produce portions of an optical image of the object (20). The imager (18) is operable to receive the portions of the image and to respond by generating sequential sets of electrical signals, wherein each set of electrical signals respresents one of the differently coloured, single colour portions of the optical image.

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REMOTE VIDEO DISPLAY SYSTEM WITH LIQUID CRYSTAL COLOUR FILTER

The invention relates to remote video display systems such as video endoscopy systems, borescopes, and other devices.

Remote video display systems display a view of the interior of a body cavity or another visually inaccessible, remote location on a video monitor. Generally, a remote video display system includes a camera processor and a camera head having an endoscope or borescope for insertion into the remote location. The camera head produces electrical signals representing an image of the remote location, and the camera processor processes the electrical signals for display on the video monitor. To produce the electrical signals, a solid-state imager such as a charge coupled device ("CCD") is located in the tip of the endoscope or in the camera head.

The camera head and endoscope are typically detachable as a unit from the control unit so that a variety of camera heads can be used with a single control unit. This offers a number of advantages. For example, if a first camera head fails, the control unit can be operated with another camera head while the first camera head is being serviced. Also, different types of camera heads, each of which may be most useful for certain procedures, can be used with a single control unit so as to avoid the expense of purchasing and maintaining multiple control units.

Presently, to render colour video images, remote video display systems such as electronic endoscopes employ mosaic colour filters situated in front of the CCD. The mosaic colour filter includes colour elements transparent to the three primary colours, the

complementary colours, or some combination thereof. The colour elements are arranged so that a specific colour is associated with each pixel of the CCD.

Other approaches to generating colour images have been used. In a first approach, a beamsplitting prism is used to divide the incident light into three beams, each of which corresponds to a primary colour and is received by a separate imager. In a second approach, a rotating filter wheel having segments corresponding to each of the primary colours is used to sequentially illuminate the object to be imaged with light of each of the primary colours.

The invention uses a solid-state colour filter to enable an imager to produce sequential, differently coloured single colour images that may be combined to produce a multi colour image. This approach offers improved resolution over the approach using a mosaic filter. When a mosaic colour filter is used, the CCD transfers all colours simultaneously. As a result, the resolution of the image produced by the CCD decreases as the colour sensitivity increases. For example, when a three-colour image is produced using a CCD and a mosaic colour filter, each of the three single colour images that make up the three-colour image is represented by a subset of the CCD's pixels. Thus, the resulting three-colour image has less resolution that a single colour image produced using all of the CCD's pixels would have. Because the solid-state colour filter of the invention produces sequential single colour images, there is no reduction in resolution of the multi colour image relative to single colour images that can be produced by the imager.

The use of a solid-state colour filter offers other advantages over the mosaic filter approach, including those of eliminating both imperfect colour

reproduction by the mosaic filter and crosstalk between elements of the mosaic filter.

Use of a solid-state colour filter also eliminates the bulky prism/imager assembly associated with the prior art beamsplitting approach, and, unlike that approach, requires only a single CCD. In addition, due to its compact size, the colour filter can be employed in an electronic endoscope in which the imager is positioned in the distal region of the endoscope.

Also, use of a solid-state colour filter eliminates the decreased system reliability that results from the presence of moving mechanical parts in the rotating filter wheel approach. When the colour filter is positioned in the camera head or the endoscope, the endoscope may be used with any light source and is not confined to operation with a light source having a colour filter wheel. As such, use of a solid-state colour filter increases the versatility and modularity of the colour remote video display system.

In one general aspect, the invention features an apparatus for viewing an image of an object. The apparatus includes a solid-state colour filter, such as a liquid crystal colour filter, and an imager. The filter is operable to produce sequential, differently coloured, single colour portions of an optical image of the object. The imager is positioned relative to the colour filter to sequentially receive the differently coloured, single colour portions of the optical image and operable to generate sequential sets of electrical signals in response thereto.

Therefore according to the present invention there is provided apparatus for viewing an image of an object, comprising:

a solid-state colour filter for sequentially transmitting differently coloured, single colour light, and

an imager positioned relative to said filter to sequentially receive differently coloured, single colour light from said object, and in response thereto to sequentially produce sets of electrical signals each of which represents an optical image of the object in said differently coloured, single colour light.

Preferred embodiments include one or more of the features described below.

The solid-state colour filter may be positioned between the object and the imager, and may be connected to the imager. When the imager (e.g., a CCD) includes a photosensitive surface and the colour filter includes a transmissive region positioned to transmit light to the photosensitive surface, the entire transmissive region of the colour filter may include common light transmission characteristics.

When the object is remotely located, the apparatus includes an insertion device, such as an endoscope, configured for insertion into the remote location. The imager and the colour filter may be positioned in the endoscope, typically in the distal region thereof. The imager and colour filter may also be positioned in a camera head to which the endoscope is connected.

In an alternative arrangement, the filter may be positioned between a light source and the object. When the object is located remotely from the light source, the apparatus may include an optical fiber positioned between the light source and the object and operable to deliver light from the light source to the object. The colour filter may be located at an end of the optical fiber near

the light source, or at the end of the optical fiber near the object.

The apparatus may also include an endoscope having a connector port for connection of the optical fiber, the endoscope being operable to deliver light received from the optical fiber through the connector port to the object. The colour filter may be attached to the connector port.

The solid-state colour filter may include a liquid crystal cell having light transmission characteristics that change in response to an electrical control signal. For example, the filter may selectively transmit only red, green, or blue light in response to the control signals.

In another general aspect, the invention features an apparatus for viewing an image of an object. The apparatus includes a solid-state colour filter, an imager, and a processor. The filter is operable to produce sequential, differently coloured, single colour portions of an optical image of the object. The imager is positioned to receive the image portions and to respond by generating sequential sets of electrical signals, each of which represents one of the differently coloured, single colour portions of the optical image. The processor is operable to receive and combine the sets of single colour electrical signals to produce multi colour video signals suitable for display as a multi colour image on a display device.

In a further embodiment of the present invention there is provided an apparatus for viewing an image of an object, comprising:

a solid-state colour filter for sequentially transmitting differently coloured, single colour light,

an imager positioned relative to said filter to sequentially receive differently coloured, single colour light from said object, and in response thereto to sequentially produce sets of electrical signals each of which represents an optical image of the object in said differently coloured, single colour light, and

a processor operable to receive and combine said sets of electrical signals to produce video signals suitable for display as a multi colour image on a display device.

The processor may include two or more memories, each of which is operable to receive and store sets of electrical signals corresponding to optical images of the object in single colours of light. In this case, the processor also includes a combiner operable to retrieve the sets of electrical signals from the memories and combine them to produce the video signals suitable for display as a multi colour image on a display device. The processor may also include circuitry, such as a demultiplexer, operable to direct the sets of electrical signals from the imager to the memories corresponding to the imager colours of the sets of electrical signals.

In another general aspect, the invention features an endoscope having a distal region for viewing an object. The endoscope includes an imager, an optical lens assembly and a colour filter. The imager has a photosensitive surface and is operable to produce electrical signals corresponding to an optical image incident on the photosensitive surface. The optical lens assembly is positioned in the distal region of the endoscope and is operable to direct an optical image of the object at the photosensitive surface of the imager. The colour filter is operable to sequentially transmit single colours of light in response to electrical control signals. The colour filter is positioned between the

imager and the optical lens assembly to sequentially direct differently coloured, single colour portions of the optical image of the object at the photosensitive surface of the imager.

Therefore in an alternative embodiment of the present invention there is provided an endoscope having a distal region for viewing an object, the endoscope comprising:

an imager having a photosensitive surface and being operable to produce electrical signals corresponding to an optical image incident on said photosensitive surface,

an optical lens assembly positioned in the distal region of said endoscope and being operable to direct an optical image of the object at the photosensitive surface of the imager, and

a colour filter operable to sequentially transmit single colours of light in response to electrical control signals, said colour filter being positioned between said imager and said optical lens assembly to sequentially direct differently coloured, single colour portions of the optical image of the object at the photosensitive surface of the imager.

In yet another general aspect, the invention features a camera head for attachment of an endoscope configured to view an object. The camera head includes an imager, an optical port and a colour filter. The imager has a photosensitive surface and is operable to produce electrical signals corresponding to an optical image incident on the photosensitive surface. The optical port is configured to receive an optical image of the object from the endoscope. The colour filter is operable to sequentially transmit single colours of light in response to electrical control signals, and is positioned between the imager and the optical port to

sequentially direct differently coloured, single colour portions of the optical image of the object at the photosensitive surface of the imager.

Further according to the present invention there is provided a camera head for attachment of an endoscope configured to view an object, the camera head comprising:

an imager having a photosensitive surface and being operable to produce electrical signals corresponding to an optical image incident on said photosensitive surface,

an optical port configured to receive an optical image of the object from the endoscope, and

a colour filter operable to sequentially transmit single colours of light in response to electrical control signals, said colour filter being positioned between said imager and said optical port to sequentially direct differently coloured, single colour portions of the optical image of the object at the photosensitive surface of the imager.

In still another general aspect, the invention features a method of generating electrical signals representative of an optical image of an object. The method includes employing a solid-state colour filter to sequentially divide the optical image of the object into differently coloured, single colour optical image portions. Each differently coloured, single colour optical image portion is received and converted into a set of electrical signals representative thereof.

According to the present invention there is also provided a method of generating electrical signals representative of an optical image of an object, comprising:

employing a solid-state colour filter to sequentially divide the optical image of the object into

differently coloured, single colour optical image portions,

sequentially receiving the differently coloured, single colour optical image portions, and

converting each of the differently coloured, single colour optical image portions into a set of electrical signals representative thereof.

Other features and advantages of the invention will become clear from the following detailed description, and from the claims.

Fig. 1 is a block diagram of a video endoscopy system.

Fig. 2 is a cross-sectional view of a camera unit of the video endoscopy system of Fig. 1.

Fig. 3 is a block diagram of signal processing circuitry of the video endoscopy system of Fig. 1.

Fig. 4 is a cross-sectional view of an alternative camera unit of the video endoscopy system of Fig. 1.

Fig. 5 is a block diagram of an alternative video endoscopy system.

Fig. 6 is a cross sectional view of a solid-state colour filter.

Figs. 7A-7C are functional diagrams illustrating operation of the colour filter of Fig. 6.

Referring to Fig. 1, a video endoscopy or borescope system 10 includes a camera head 12 and a camera processor 14 connected by a cable 15. Camera head 12 includes an endoscope 16 for insertion into a remote region such as a body cavity. An imaging device, such as a CCD 18 (see Figs. 2 and 3), within endoscope 16 produces electrical signals representative of an optical image of an object 20 located in the distal region 22 of endoscope 16. Camera processor 14 processes the electrical signals produced by CCD 18 to generate a video image that is displayed on a video monitor 24.

Endoscopes and video endoscopy systems are described, for example, in copending application serial number 07/958,688, entitled "Endoscope with Focusing Mechanism" and filed October 9, 1992, and copending application serial number 08/200,197, entitled "Camera Head with Memory" and filed February 23, 1994, both of which are incorporated by reference.

A light source 26 in a light unit 28 provides light to illuminate object 20. The light is provided through an optical fiber 30 positioned between light source 26 and the distal region of endoscope 16.

Camera processor 14 includes a microprocessing unit ("MPU") 32, a filter driver ("FD") 34, a CCD driver ("CD") 36, and signal processing ("SP") circuitry 38. In operation, MPU 32 provides control signals to filter driver 34. In response to these control signals, filter driver 34 causes a liquid crystal colour filter 40 (see Fig. 2) to become transparent to a sequence of colours.

MPU 32 also provides control signals to CCD driver 36. These signals, which are synchronized with the control signals provided to filter driver 34, cause CCD driver 36 to transmit driving signals to CCD 18 (see Figs. 2 and 3). In response to the driving signals, CCD 18 produces electrical signals representing an image of object 20, and transmits the electrical signals to signal processing circuitry 38. As liquid crystal colour filter 40 becomes transparent to each colour in the sequence of colours, CCD 18 transmits to signal processing circuitry 38 a single colour image of object 20 in that colour.

Signal processing circuitry 38 processes the electrical signals from CCD 18 and converts them to video signals for display of the image on video monitor 24. Based on the electrical signals representing the sequence of single colour images, and in response to synchronizing

signals from MPU 32, signal processing circuitry 38 generates a single multi colour image for display on monitor 24. Colour filter 40 transitions from colour to colour at a rate that permits CCD 18 to provide a different single colour image on the order of once every 10 milliseconds. This permits multi colour video display of even fast moving scenes without colour blurring.

In the embodiment illustrated in Fig. 2, liquid crystal colour filter 40 is positioned in the distal region 22 of endoscope 16 between an objective lens assembly 42 and CCD 18. Colour filter 40 receives control signals from filter driver 34 through a connector 44 in cable 15. CCD 18 receives control signals from CCD support circuitry 46 in camera head 12 through a connector 48. CCD support circuitry 46 receives control signals from CCD driver 36 through a connector 50 in cable 15. CCD 18 provides electrical image signals to CCD support circuitry 46 through a connector 52, and CCD support circuitry 46 provides the electrical image signals to signal processing circuitry 38 through a connector 54 in cable 15.

An optical fiber 56 connected to optical fiber 30 delivers "white" light to the distal region 22 of endoscope 16. Fiber 56 passes between an inner wall 58 and an outer wall 60 of endoscope 16. Light from fiber 56 is reflected by object 20 to produce an image that is incident on objective lens assembly 42. Lens assembly 42 focuses the image on a photosensitive surface 19 of the CCD 18 through colour filter 40.

In response to control signals from filter driver 34, the transmittance characteristics of colour filter 40 sequentially change so that filter 40 is sequentially transparent to red, green or blue light. As such, filter 40 sequentially provides to CCD 18 images representative of the red, green and blue portions of the image of

object 20. The Filter 40 defines a light transmission region that corresponds in size and position to the photosensitive surface 19 of CCD 18. At any given time, this entire light transmission region has common light transmission characteristics. In the described embodiment, colour filter 40 is an RGB FASTfilter available from Displaytech of Boulder, Colourado.

Referring to Fig. 6, colour filter 40 includes two ferroelectric liquid crystal (FLC) cells 100 (FLC1) and 102 (FLC2). When a positive five volt differential is applied between leads 104 and 106 or leads 108 and 110 of connector 44, the optic axis of the corresponding FLC cell 100 or 102 is oriented in a first direction. When a negative five volt differential is applied between leads 104 and 106 or leads 108 and 110 of connector 44, the optic axis of the corresponding FLC cell 100 (FLC1) or 102 (FLC2) is shifted by 45° relative to the first direction.

Each of FLC cells 100 (FLC1) and 102 (FLC2) is oriented so that the optic axis of the cell is vertically oriented when a positive five volt differential is applied to its leads. In this orientation, the FLC cell leaves the polarization of either vertically or horizontally polarized light unchanged (i.e., the FLC cell is "off"). When the optic axis of the FLC cell is tilted 45° (by changing the voltage differential applied to its leads to negative five volts), the cell rotates the polarization of vertically or horizontally polarized light by 90° (i.e., the FLC cell is "on").

Colour filter 40 also includes two coloured polarizers and a neutral polarizer. The first coloured polarizer 112 (POL1) passes vertically polarized red light and horizontally polarized cyan (blue and green) light. The second coloured polarizer 114 (POL2) passes vertically polarized yellow (red and green) light and

horizontally polarized blue light. The neutral polarizer 116 (POL3) passes all vertically polarized light and absorbs all horizontally polarized light.

As illustrated in Fig. 2, colour filter 40 is mounted directly to the photosensitive surface 19 of the CCD 18. Colour filter 40 could also be mounted in a separate housing.

Referring to Fig. 7A, colour filter 40 passes red light when positive five volt differentials are applied to both FLC cell 100 and FLC cell 102 (i.e., both FLC cells are off). Assuming that the light incident on colour filter 40 includes both vertically and horizontally polarized red, green and blue components, the light passing through polarizer 112 (POL1) includes a vertical red component and horizontal green and blue components. This light is unaffected as it passes through FLC cell 100 (FLC1). Next, polarizer 114 (POL2) eliminates the horizontal green component so that the resulting light includes the vertical red component and the horizontal blue component. This light is unaffected as it passes through FLC cell 102 (FLC2). Finally, the polarizer 116 (POL3) eliminates the horizontal blue component so that only the vertical red component remains.

Referring to Fig. 7B, colour filter 40 passes green light when the a negative five volt differential is applied to FLC cell 100 (FLC1) and a positive five volt differential is applied to FLC cell 102 (FLC2) (i.e., FLC1 is on and FLC2 is off). As noted above, the light passing through polarizer 112 (POL1) includes a vertical red component and horizontal green and blue components. As this light passes through FLC cell 100 (FLC1), the cell changes the polarity of the light to include a horizontal red component and vertical green and blue components. Polarizer 114 (POL2) eliminates both the

horizontal red component and the vertical blue component so that the resulting light includes only the vertical green component. This light is unaffected as it passes through FLC cell 102 (FLC2) and polarizer 116 (POL3).

Referring to Fig. 7C, colour filter 40 passes blue light when a positive five volt differential is applied to FLC cell 100 (FLC1) and a negative five volt differential is applied to FLC cell 102 (FLC2) (i.e., FLC1 is off and FLC2 is on). As noted above, the light passing through polarizer 112 (POL1) includes a vertical red component and horizontal green and blue components. This light is unaffected by FLC cell 100 (FLC1), but has its horizontal green component eliminated by polarizer 114 (POL2) so that the resulting light includes the vertical red component and the horizontal blue component. As this light passes through FLC cell 102 (FLC2), the cell changes the polarity of the light to include a horizontal red component and a vertical blue component. The polarizer 116 (POL3) eliminates the horizontal red component so that only the vertical blue component remains.

Referring to Fig. 3, signal processing circuitry 38 includes a demultiplexer 62. In response to a control signal from MPU 32, demultiplexer 62 provides the signal received from CCD 18 through connector 54 to either a red image memory 64, a blue image memory 66, or a green image memory 68. The control signal that controls demultiplexer 62 is synchronized with the control signal provided to filter driver 34 so that demultiplexer 62 provides the signal from CCD 18 to the memory associated with the colour transmitted by colour filter 40. The same control signal activates the memory 64, 66 or 68 to which demultiplexer 62 directs the signal from CCD 18. For example, when filter driver 34 causes colour filter

40 to be transparent to green light, green image memory 68 is activated and demultiplexer 62 transmits the signals from CCD 18 to green image memory 68.

A combiner 70 receives from red, blue and green memories 64, 66 and 68 signals corresponding to the single colour images and produces an RGB signal corresponding to a multi colour image. Combiner 70 produces the RGB signal at the same rate as CCD 18 produces the signals corresponding to single colour images. Accordingly, one colour component of each multi colour image is updated relative to the previous multi colour image. Combiner 70 could also produce the RGB signal at different rates. For example, combiner 70 could produce the RGB signal at one third the rate of CCD 18 so that every colour component of each multi colour image is updated relative to the previous multi colour image.

A digital camera 72 receives the RGB signal from combiner 70 and generates the video signal displayed on monitor 24.

Other embodiments are within the scope of the following claims.

For example, as illustrated in Fig. 4, CCD 18 and colour filter 40 may be positioned within camera head 12. In this embodiment, an optical relay system 74 in endoscope 16 receives the image from objective lens assembly 42 and transmits it to camera head 12. In camera head 12, a focussing lens 76 focuses the image on the photosensitive surface 19 of CCD 18 through colour filter 40. Optical relay system 74 may be, for example, a coherent fiber bundle, a rod-like lens assembly, or any suitable lens assembly. Such a lens assembly is described, for example, in copending application serial number 08/262,736, entitled "Relay Lens Assembly and Method of Manufacture" and filed June 20, 1994, which is

incorporated by reference. Colour filter 40 may be positioned in the distal region of endoscope 16 while CCD is positioned within camera head 12.

In yet another embodiment, as illustrated in Fig. 5, colour filter 40 is removed from its position between object 20 and CCD 18 and is placed between light source 26 and object 20. In this embodiment, a filter assembly 78 is placed between sections 30a and 30b of optical fiber 30. Filter assembly 78 includes a collimating lens 80 that passes white light from optical fiber 30a through colour filter 40. As discussed above, colour filter 40 transmits a portion of the light and thereby produces coloured light. A focussing lens 82 receives the coloured light from colour filter 40 and passes it through optical fiber 30b to the distal region 22 of endoscope 16. Thus, rather than sequentially providing CCD 18 with differently coloured, single colour portions of a multi colour image of object 20, object 20 is sequentially illuminated with differently coloured light to provide CCD 18 with differently coloured, single colour images.

To minimize or prevent light energy losses due to filter assembly 78, the collimating and focusing lenses 80, 82 are located in close proximity to the colour filter 40, or are designed as faces of the colour filter 10. Filter assembly 78 can be produced in miniature size and attached directly to the illumination channel entrance of the endoscope 16. Alternatively, filter assembly 78 may be disposed at the output of light source 26, or integrated therein.

In addition, the endoscope may be of any type. For example, it could be flexible, rigid or semirigid, and could include an operation channel for insertion of a surgical instrument, or for suction or irrigation. Also, although an endoscope for visually inspecting a body

cavity has been described, the invention is equally applicable for use with borescopes or other visualization devices.

CLAIMS

1. Apparatus (10) for viewing an image of an object, comprising:

a solid-state colour filter (40) for sequentially transmitting differently coloured, single colour light, and

an imager (18) positioned relative to said filter (40) to sequentially receive differently coloured, single colour light from said object, and in response thereto to sequentially produce sets of electrical signals each of which represents an optical image of the object in said differently coloured, single colour light.

2. The apparatus (10) of claim 1, wherein said solid-state colour filter (40) is positioned between the object and said imager (18).

3. The apparatus (10) of claim 2, wherein said solid-state colour filter (40) is connected to said imager (18).

4. The apparatus (10) of claim 2, wherein said imager (18) includes a photosensitive surface (19) and said colour filter includes a transmissive region positioned to transmit light to said photosensitive surface (19), and wherein the entire transmissive region of said colour filter (40) includes common light transmission characteristics.

5. The apparatus (10) of claim 2, wherein the object is positioned in a remote location and wherein said apparatus further comprises an insertion device configured for insertion into the remote location.

6. The apparatus (10) of claim 5, wherein said imager (18) and said colour filter (40) are positioned in said insertion device.

7. The apparatus (10) of claim 5, wherein said insertion device comprises an endoscope (16).

8. The apparatus (10) of claim 7, further comprising a camera head (12), said endoscope having a proximal region connected to said camera head and a distal region (22) for insertion into the remote location.

9. The apparatus (10) of claim 8, wherein said imager (18) and said colour (40) filter are positioned in the distal region of said endoscope (16).

10. The apparatus (10) of claim 8, wherein said imager (18) and said colour (40) filter are positioned in said camera head (12).

11. The apparatus (10) of claim 2, wherein said apparatus further comprises a camera head (12) having a connector operable for attachment of an endoscope (16), and wherein said imager (18) and said colour (40) filter are positioned in said camera head (12).

12. The apparatus (10) of claim 1, further comprising a light source (26) operable to illuminate the object, wherein said solid-state colour filter (40) is positioned between said light source (26) and the object.

13. The apparatus (10) of claim 12, wherein the object is located remotely from said light source (26), the apparatus further comprising an optical fiber (30)

positioned between the light source and the object and operable to deliver light from the light source (26) to the object.

14. The apparatus of claim 13, wherein the colour filter (40) is located at an end of the optical fiber (30) near the light source.

15. The apparatus of claim 13, wherein the colour filter (40) is located at an end of the optical fiber (30) near the object.

16. The apparatus (10) of claim 15, further comprising an endoscope (16) having a connector port for connection of said optical fiber (30), the endoscope (16) being operable to deliver light received from said optical fiber (30) through said connector port to the object.

17. The apparatus (10) of claim 16, wherein the colour filter (40) is attached to said connector port.

18. The apparatus (10) of claim 1, wherein the solid-state colour filter includes a liquid crystal cell (100,102) having light transmission characteristics that change in response to an electrical control signal.

19. The apparatus (10) of claim 1, wherein the solid-state colour filter (40) selectively transmits only red, green, or blue light in response to control signals.

20. The apparatus (10) of claim 1, wherein the imager is a charged coupled device (18).

21. Apparatus (10) for viewing an image of an object, comprising:

a solid-state colour filter (40) for sequentially transmitting differently coloured, single colour light,

an imager (18) positioned relative to said filter (40) to sequentially receive differently coloured, single colour light from said object, and in response thereto to sequentially produce sets of electrical signals each of which represents an optical image of the object in said differently coloured, single colour light, and

a processor (14) operable to receive and combine said sets of electrical signals to produce video signals suitable for display as a multi colour image on a display device (24).

22. The apparatus (10) of claim 21, wherein said solid-state colour filter (40) is positioned between the object and said imager (18).

23. The apparatus (10) of claim 21, comprising an endoscope (16) for transmitting the image of the object to the imager (18).

24. The apparatus (10) of claim 22, further comprising a camera head (12), said endoscope (16) having a proximal region connected to said camera head (12) and a distal region (22) for placement near the object.

25. The apparatus (10) of claim 24, wherein said imager (18) and said colour filter (40) are positioned in the distal region (22) of said endoscope.

26. The apparatus (10) of claim 24, wherein said imager (18) and said colour filter (40) are positioned in the camera head (12).

27. The apparatus (10) of claim 21, wherein said processor (14) includes:

a plurality of memories, each of which is operable to receive and store sets of electrical signals corresponding to optical images of the object one of the single colours of light,

a combiner (70) operable to retrieve sets of electrical signals from each of the memories and to combine them to produce the video signals suitable for display as a multi colour image on a display device(24).

28. An endoscope (16) having a distal region (22) for viewing an object, the endoscope (16) comprising:

an imager (18) having a photosensitive surface (19) and being operable to produce electrical signals corresponding to an optical image incident on said photosensitive surface,

an optical lens assembly positioned in the distal region (22) of said endoscope (16) and being operable to direct an optical image of the object at the photosensitive surface (19) of the imager (18), and

a colour filter (40) operable to sequentially transmit single colours of light in response to electrical control signals, said colour filter (40) being positioned between said imager (18) and said optical lens assembly to sequentially direct differently coloured, single colour portions of the optical image of the object at the photosensitive surface (19) of the imager (18).

29. A camera head (12) for attachment of an endoscope (16) configured to view an object, the camera head (12) comprising:

an imager having a photosensitive surface and being operable to produce electrical signals corresponding to an optical image incident on said photosensitive surface (19),

an optical port configured to receive an optical image of the object from the endoscope (16), and

a colour filter (40) operable to sequentially transmit single colours of light in response to electrical control signals, said colour filter being positioned between said imager (18) and said optical port to sequentially direct differently coloured, single colour portions of the optical image of the object at the photosensitive surface (19) of the imager (18).

30. A method of generating electrical signals representative of an optical image of an object, comprising:

employing a solid-state colour filter (40) to sequentially divide the optical image of the object into differently coloured, single colour optical image portions,

sequentially receiving the differently coloured, single colour optical image portions, and

converting each of the differently coloured, single colour optical image portions into a set of electrical signals representative thereof.

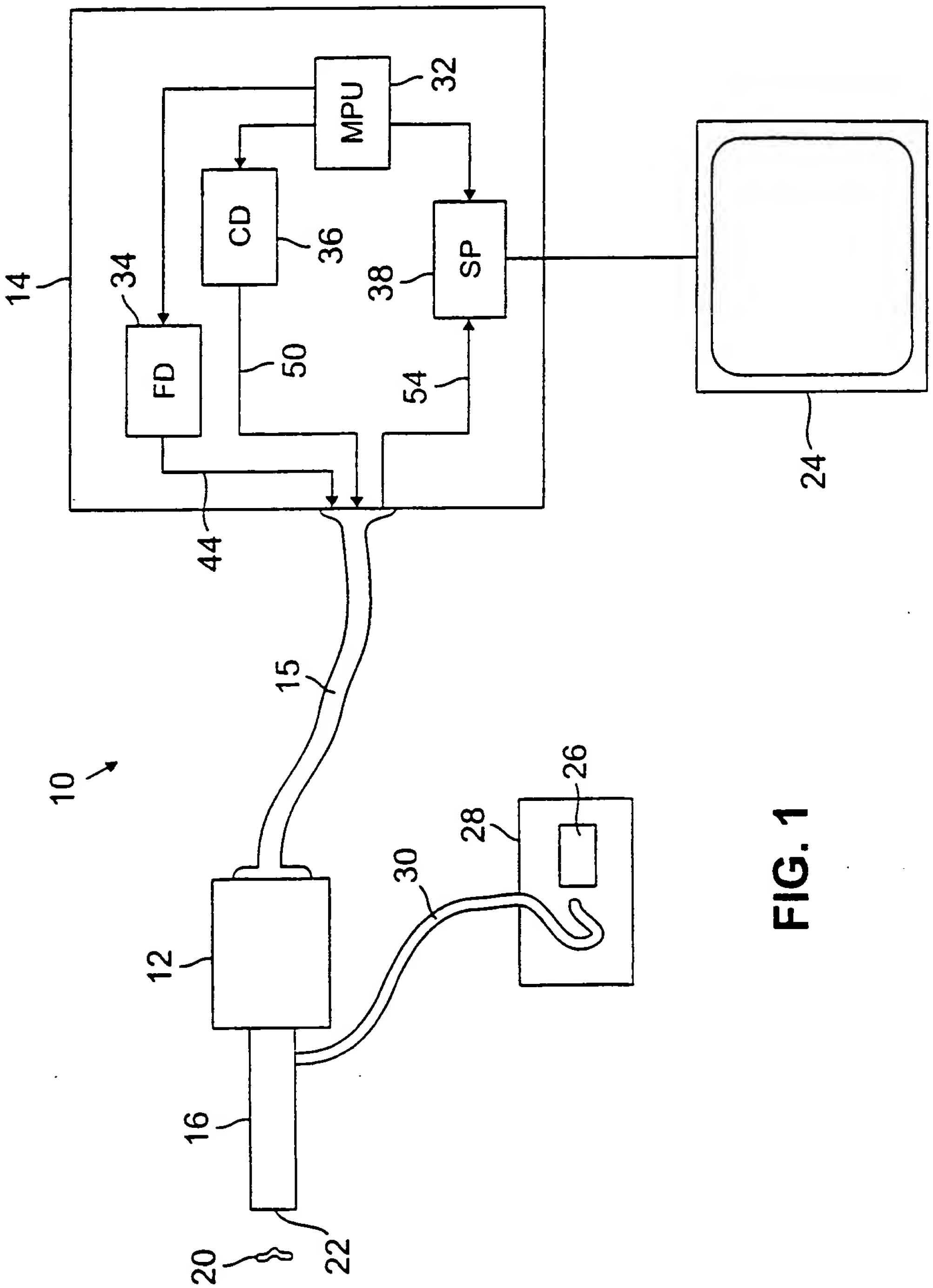

FIG. 1

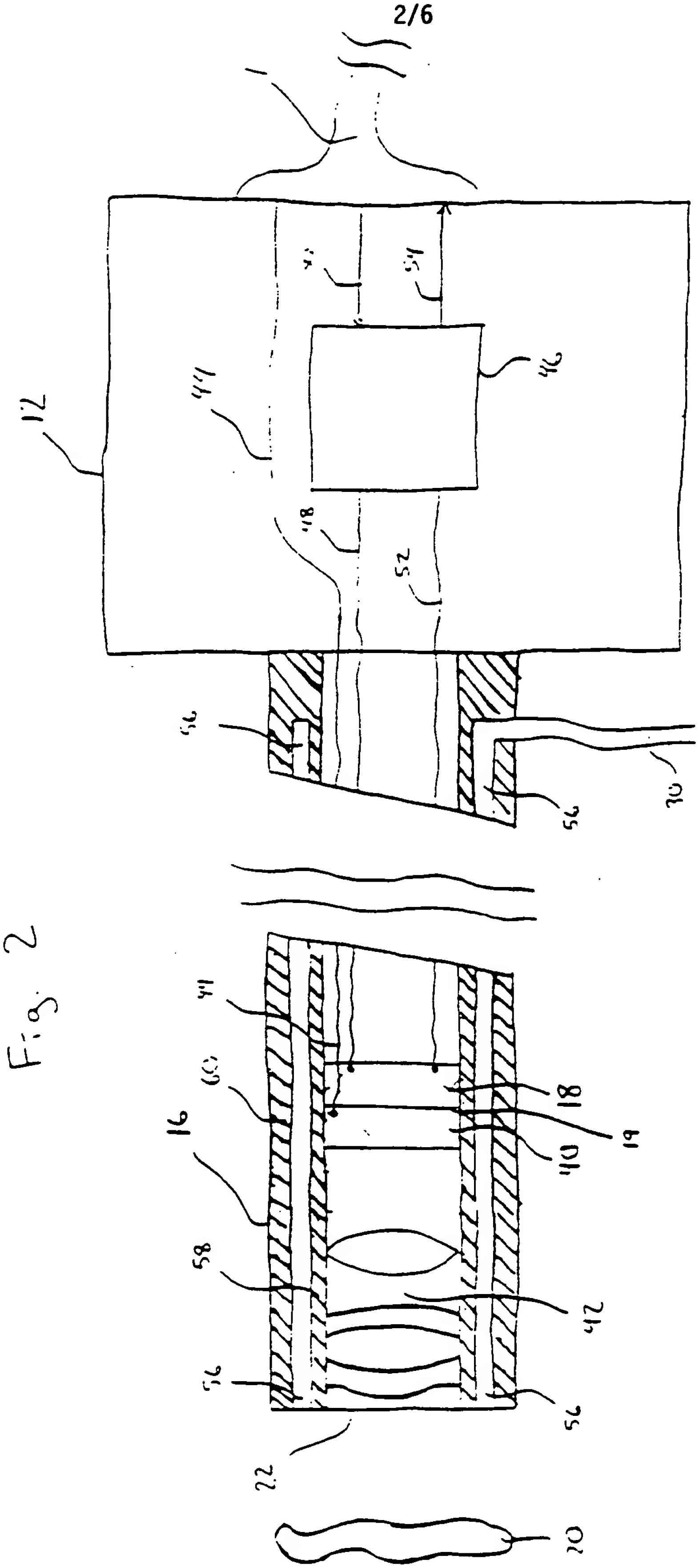

Fig. 2

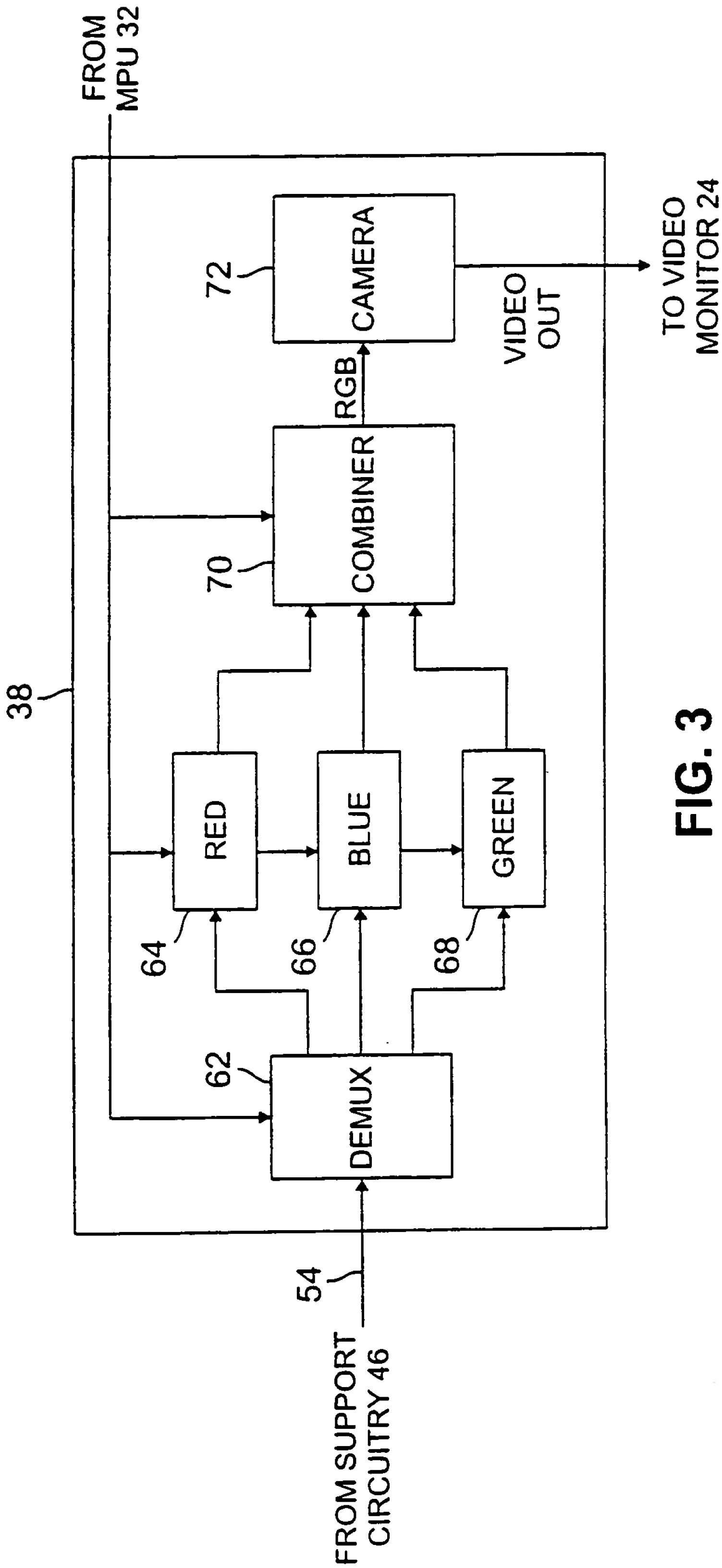
FROM MPU 32
38
72
CAMERA
RGB
VIDEO OUT
TO VIDEO MONITOR 24
70
COMBINER
RED
BLUE
GREEN
64
66
68
62
DEMUX
54
FROM SUPPORT CIRCUITRY 46

FIG. 3

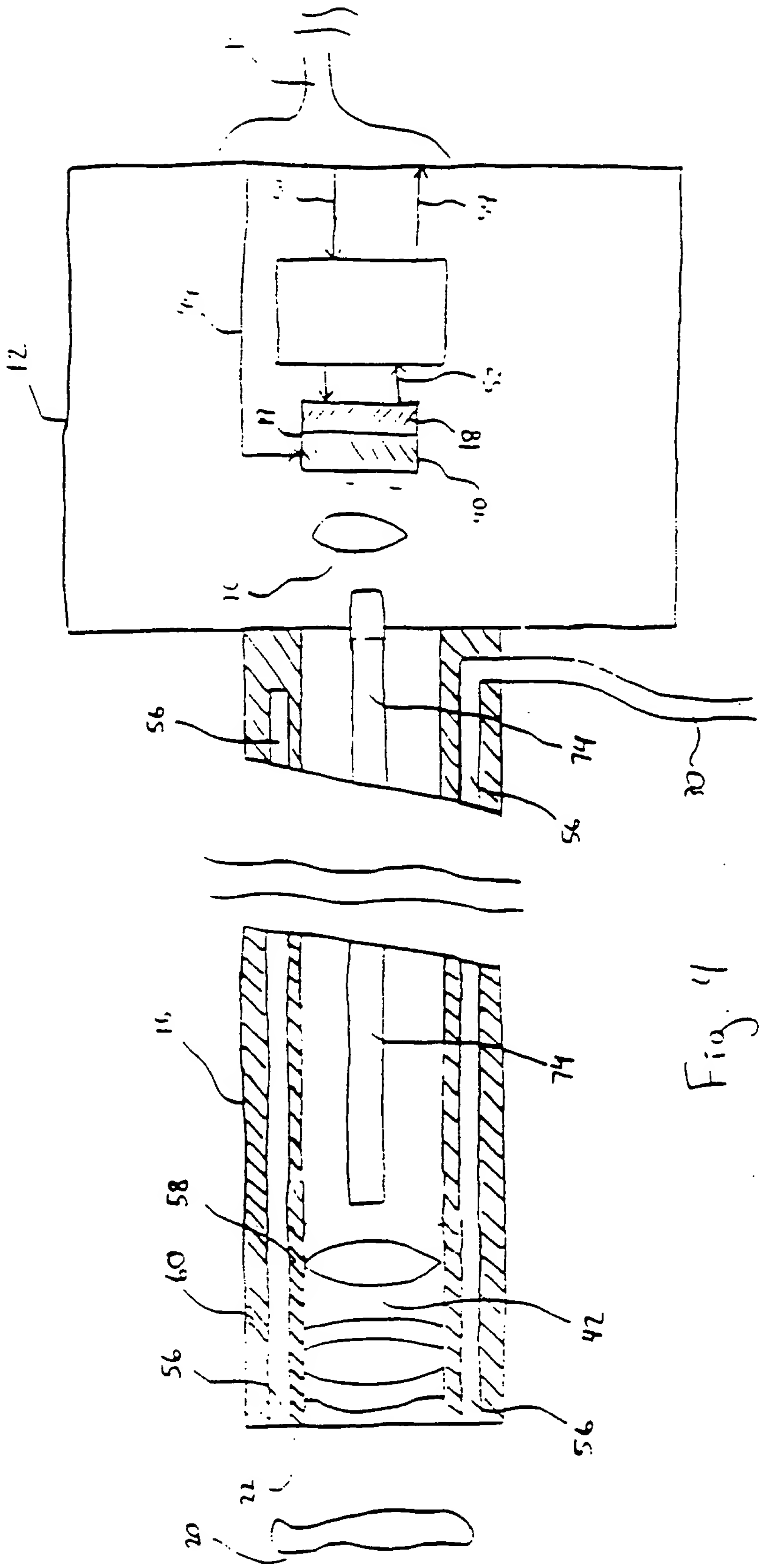

Fig. 4

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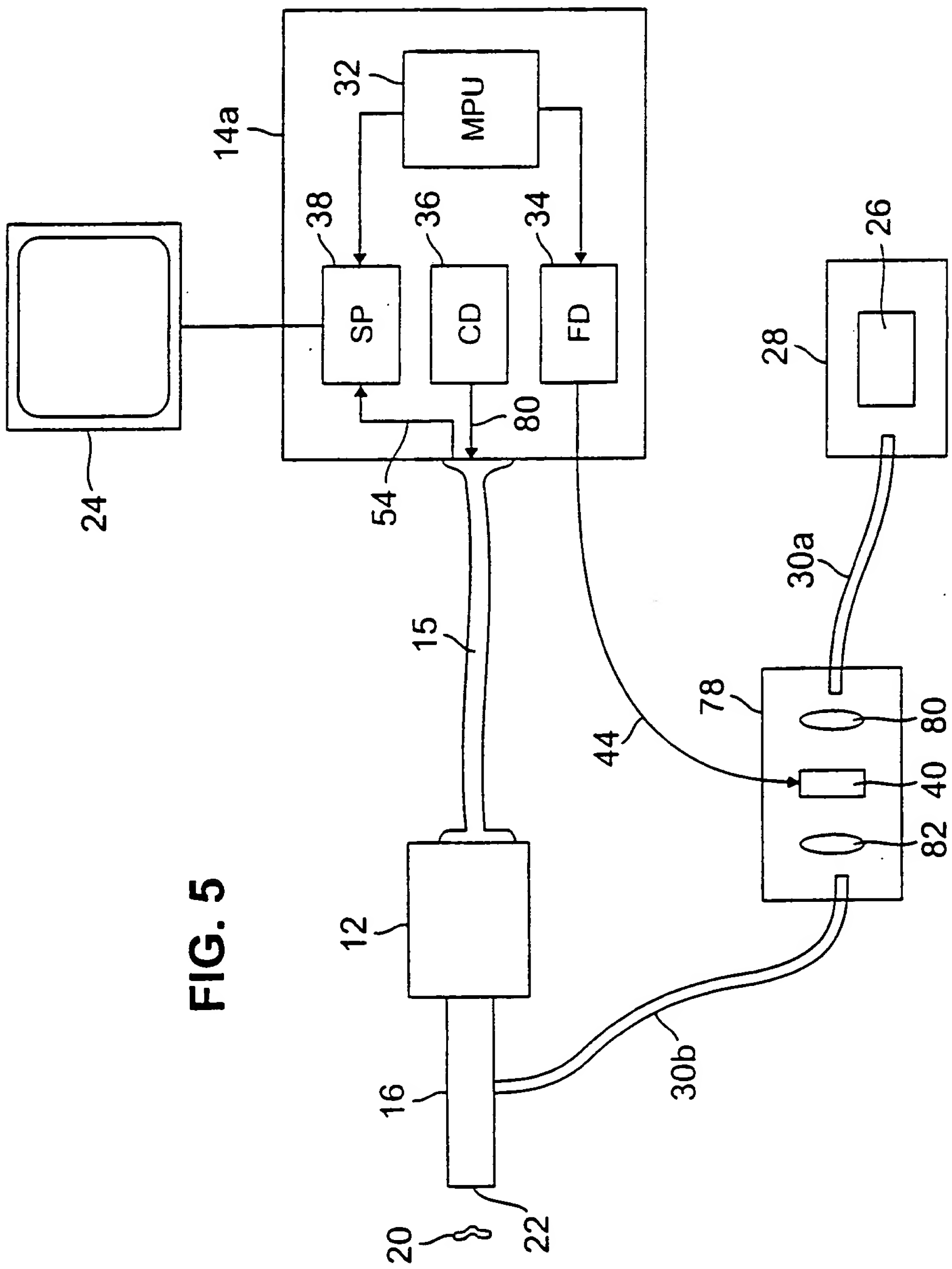
14a
32
MPU
38
36
34
SP
CD
FD
24
80
54
15
44
26
28
30a
78
80
40
82
12
16
30b
20
22

FIG. 5

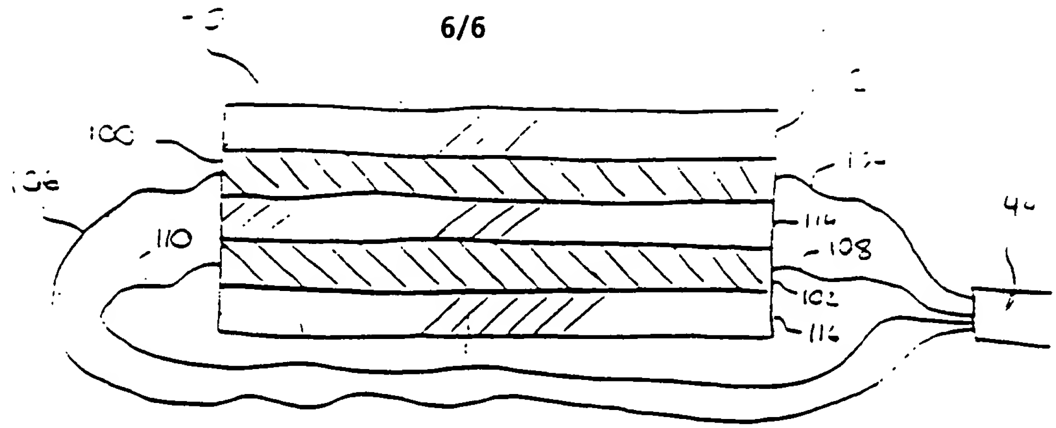

Fig. 6

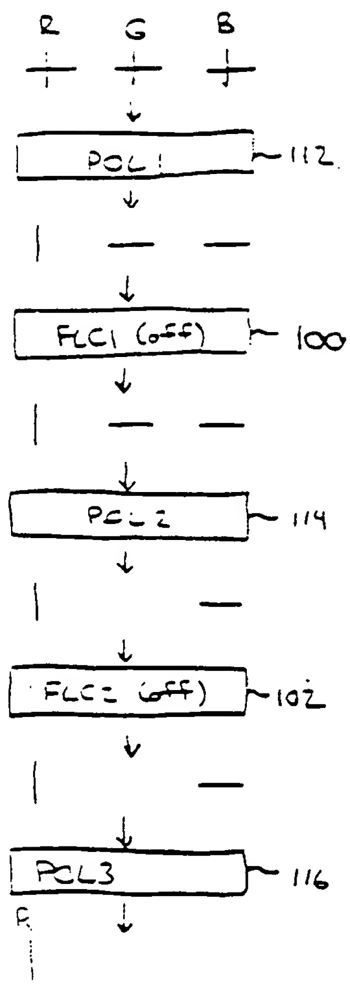

Fig. 7A

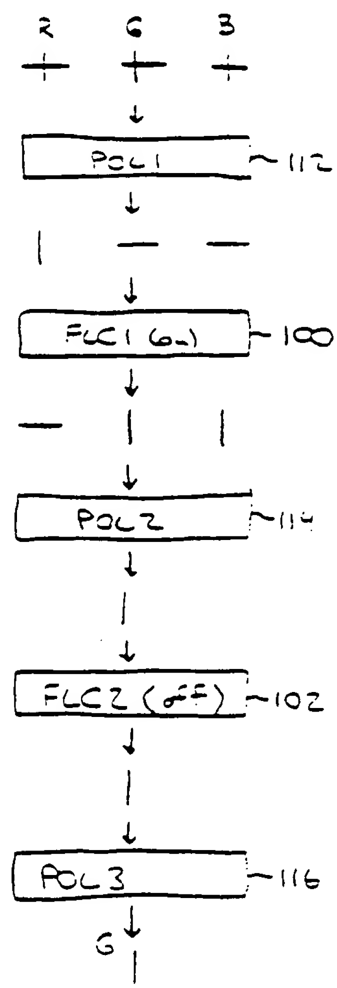

Fig. 7B

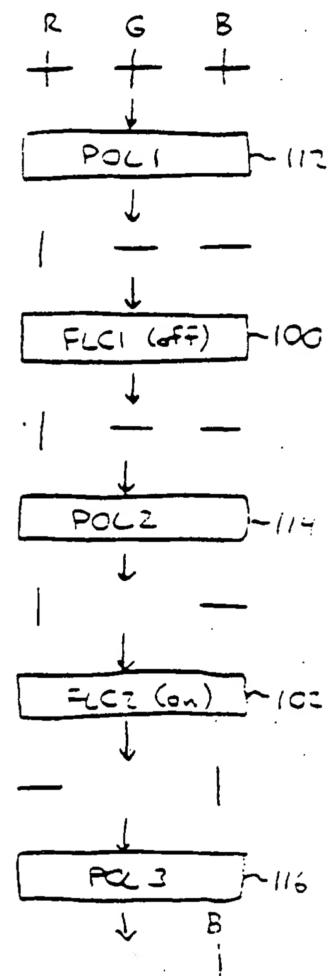

Fig. 7C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/13600

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04N 7/18
US CL :348/70
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/70,65,68,68,71,75,72,73

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,278,642 (DANNA ET AL) 11 JANUARY 1994, see fig. 2 and entire document.	1-9, 12-13, 15-16, 18-25, 28-30 --- 10, 11, 14, 17, 26-27
Y	US, A, 4,870,488 (IKUNO ET AL) 26 SEPTEMBER 1989, see fig. 5.	10, 11, 14, 17, 26
Y	US, A, 4,638,353 (NAGASAKI ET AL) 20 JANUARY 1987, see fig. 10.	27
Y	"RGB FASTfilter," by Displaytech, Inc., Boulder, Colorado, Revison. 5/1994.	1-30

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04N 7/18

A1

(11) International Publication Number: WO 97/08897

(43) International Publication Date: 6 March 1997 (06.03.97)

(21) International Application Number: PCT/US96/13600

(22) International Filing Date: 22 August 1996 (22.08.96)

(30) Priority Data:
08/518,314 23 August 1995 (23.08.95) US

(81) Designated States: AU, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

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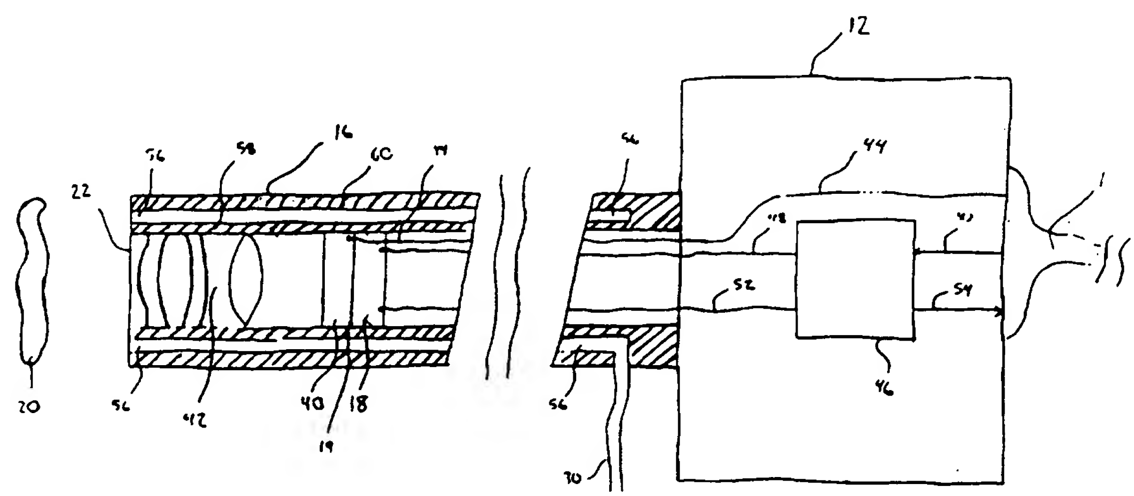
(54) Title: REMOTE VIDEO DISPLAY SYSTEM WITH LIQUID CRYSTAL COLOUR FILTER



(57) Abstract

An apparatus for viewing an object includes a solid-state colour filter (40) and an imager (18) such as a charge coupled device. The solid state colour filter (40) is operable to produce sequential, differently-coloured, single colour portions of an optical image of the object (20). The imager (18) is operable to receive the portions of the image and to respond by generating sequential sets of electrical signals, wherein each set of electrical signals represents one of the differently coloured, single colour portions of the optical image.

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